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ABSTRACT

Stressing the use of hands-on activities, this guide contains ideas and suggestions for teaching model rocketry to junior high school students. It is intended to be used as a supplemental unit to the existing science curriculum. The unit includes a listing of goals and objectives that are designed to be used by the teacher to correlate this unit with the course's goals and objectives. Seven proficiency requirements are described and are based on the objectives. A suggested instructional sequence is provided and is also designed to correspond directly with the stated objectives. Each of the seven instructional activities is described. The model rocketry safety code of the National Association of Rocketry and the Hobby Industry of America is included. (TW)

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COURSE GUIDE:

MODEL ROCKETRY
in the
Middle School/Junior High School
(Grades 6-9)

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His professional teaching experience encompasses 20 years, including eight years at the K-12 level and 12 years at the college level. As the State Science Consultant for the Iowa State Department of Education (1972-75), he served as the director of several state-wide projects. Dr. Downs is active in state and national science education organizations and was the 1981-82 president of the National Science Supervisors Association. He has published numerous books and journal articles and served as a consultant to numerous government and private organizations. He has also been the recipient and coordinator of several large National Science Foundation grants and many state and/or local grants.

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COURSE DESCRIPTION

This activity guide contains ideas and suggestions for teaching model rocketry. This will be developed using many hands-on activities that may be used with junior high students. All of the suggestions given will not have to be used to have a fun and successful unit. The unit should be used as supplemental material to the existing school curriculum. The teacher should choose to use the unit where he/she believes it most appropriately complements the existing science curriculum.

Model rocketry is an activity that can provide enjoyment, excitement, and considerable student learning. It is an activity that involves much motion and can be readily studied using the learning processes. Model rocketry generates high motivation, uses hands-on activities, and involves important applications for science and mathematics content. The Estes acronym F.R.O.G.S., meaning Fun Rocketry Or Great Science aptly represents the relationship between model rocketry and science.

PHILOSOPHY

The study of science offers a knowledge of natural phenomena that uniquely rests upon the notion that humans can test and understand the orderly nature of the universe. Fundamental to this proposition is a need for students to develop and apply the logical thought processes of science as a part of their basic learning. The processes are best developed through a well-articulated science program that includes experimentation and manipulation of materials.[1]

This author believes students learn science best by active participation. Knowledge is gained by using fundamental learning processes. Research by Jean Piaget indicates that an experientially based (hands-on) science program is preferred, together with an inquiry approach that capitalizes on the student's natural curiosities. A unit focusing on "model rocketry" should make it possible for the teacher to build on the student's natural curiosities and include much experimentation and manipulation of materials.

1. Gerlovich, Jack A., Downs, Gary E., and Others. A Tool for Assessing and Revising the Science Curriculum. Des Moines, Iowa. Department of Public Instruction. p.14.

GOALS AND OBJECTIVES

The following goals and objectives may be used by the teacher to help direct the student learning for this unit.

Goal: The students should 1) use the processes to acquire knowledge as to what propels and guides a rocket for proper flight and 2) gain an appreciation for the contributions rockets have made to modern society.

Objectives:

1. 1 The student should be able to correctly build a functional Estes Alpha rocket (skill level 1). (Students who have already built an Alpha rocket may desire to build a skill level 2 model.)

1. 2 The student should learn the Model Rocket Safety Code and adhere to it during all model rocketry activities.

1. 3 The student should be able to prepare the model rocket he/she built for a safe launch.

1. 4 The student should be able to use the observing process during model rocket launching to collect flight data.

1. 5 The student should be able to successfully analyze collected flight data (i.e., make predictions, inferences, and hypotheses).

1. 6 The student should be able to state a hypotesis related to model rocketry flights, and then plan an experiment to test the hypotesis (processes of controlling variables, interpreting data, and the basic processes should be used).

1. 7 The student should be able to write a three or four page report on the contributions rockets have made to modern society.

PROFICIENCY REQUIREMENTS

The proficiency that a teacher desires of his/her students should depend upon the type of student being taught. The proficiency for any student should be based upon the accomplishment of the stated objectives. The following proficiency statements are based upon the objectives written for this unit. (The proficiency numbers correspond to the objective numbers.)

Proficiency 1.1: The teacher should require all students to construct a model rocket that will fly.

Proficiency 1.2: There are 14 separately stated rules that make up the NAR/HIA* Model Rocketry Safety Code. Every student should be required to sign a promise to follow the rules. Every student should also be required to write or state verbally what each of the 14 rules state when given the rules' identifying titles.

Proficiency 1.3: Each student should prepare his/her rocket for launching; load recovery wadding; fold and load parachute; place nose cone in properly; load engine; load engine igniter; place on launch pad; properly connect wires from launch controller; and launch rocket. The teacher must check for successful completion of all steps. Safety must be a controlling factor during evaluation of all steps.

Proficiency 1.4: The teacher should have each student record observational statements about each rocket launched. The senses of sight (used to record data about height and to watch the flight path), smell (student should be instructed to smell burned engines), feeling (students should feel the warmth of an engine soon after recovery), and hearing (students should record in writing the sound model rockets make when launched) should be used during model rocket launchings. All students should be expected to use all of the above stated four senses during launching activities.

Proficiency 1.5: The teacher should have the students analyze the data collected during rocket flights. Students should be expected to use a balance and measure the mass of rocket to $\pm$ one tenth of a gram of the accepted value (teacher's determined mass). Using data collected during flights, students should be expected to analyze the rockets and make correct predictions

*National Association of Rocketry/Hobby Industry of America

as to why one rocket goes higher than another like rocket (to satisfaction of teacher). Students should also be expected to make correct predictions related to rocket heights achieved by different rockets using 1/2A6-2 and A8-3 engines (to the satisfaction of the teacher).

Proficiency 1.6: Students should be expected to write hypotheses related to model rocketry. The students should then be expected to design controlled experiments to test the stated hypotheses. The teacher should check the designed experiments for logical development, workable considerations, and safety aspects. The students should be expected to use the integrated and basic processes to accomplish this task. The experiments should be actually carried out when safe and feasible.

Proficiency 1.7: The reports students write should be checked for grammar and content accuracy. The teacher should expect the reports to be of equal quality to reports written for English, social studies, and other disciplines.

INSTRUCTIONAL SEQUENCE

The following instructional sequence is suggested for the teacher to use. Each of the numbered activities corresponds directly with the earlier stated objectives.

Activities: A good initial activity for the teacher to use for this unit is to blow up a balloon and let it go in front of the class. Discuss what causes the balloon to move (forces) and why.
A second activity for the teacher to use could be the controlled balloon activity. Hang a taut smooth string across the room. Thread a drinking straw or a piece of a drinking straw (a 4 cm piece) on the taut string. The teacher can now tape balloons to the straw and control the flight of the balloons. This is a good activity to focus on controlling variables and collecting data while manipulating certain variables. Such variables could be how much air was forced into the balloon or size of balloon used.

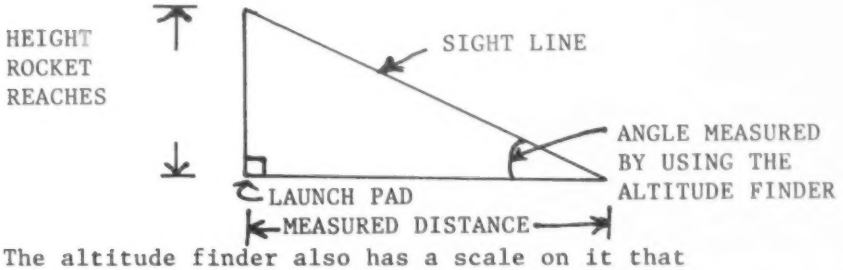
Activity 1.1 The teacher should have the school or the students purchase Estes Alpha Rockets (skill level 1). If some students have had sufficient experience building skill level one rockets then they should be encouraged to build a skill level two rocket. If the teacher has not had any personal experience building Estes rockets, then he/she should build one prior to having students build their rockets. It is advantageous to have several model rockets in several different stages of completion for students to observe while building their rockets. Students must be reminded to read all directions very carefully before starting to build their rockets. Students must follow the directions very carefully. Students who have had previous experience building model rockets could be used as teacher-helpers during the construction phase. They should make sure, however, that each student does his/her own work. The teacher needs to make sure sufficient glue is used to secure the fins and the launching lug to the rocket body. It is much safer to use too much glue than not enough.

Activity 1.2 The teacher should make sure each student has a copy of the NAR/HIA Model Rocketry Safety Code. (This code is printed in every Estes Model Rocket Catalog and on other printed material published by Estes.) The teacher should discuss each of the fourteen points with the students and then have each student sign a copy of the code. These should be kept in the teacher's personal class file. A copy of the

code should be posted in the classroom in a very conspicuous place. One word of warning for the teacher - never allow students to use any rocket engines except the NAR-approved solid propellant engines.

Activity 1.3 The teacher should check each student's rocket for adequate glue for holding on the fins, launch lug, and engine holder before the students are permitted to load the rocket with an engine. The recovery system should be checked for durable construction and attachment. The fit of the nose cone into the body tube should be checked. The teacher wants to make sure appropriate size engines (Estes kit instructions specify the proper engines for each kit.) are being used. Students may need some help when placing the igniters in the engines. The igniters are somewhat delicate and must be handled with care. The end of the igniters must press against the solid propellant for the engine to fire when the igniter is electrically heated.

Activity 1.4 The teacher should choose a calm day for launching the students' rockets. All students not collecting data or helping fire the rockets should be in a semicircle at least 6 meters behind the launching pad. All students should have data tables to use to enter collected data during the launching periods. Different teams of students can be assigned to use the Estes altitude finder or student-made altitude measurers. Angles can be read and then by constructing a real triangle on the ground or using similar triangles on paper the students should be able to determine the height each rocket reached.

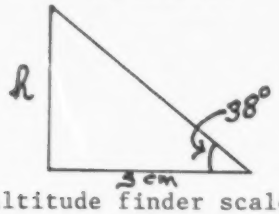


The altitude finder also has a scale on it that can be used to instantly determine the height reached. This value could be compared to the values students calculate.

Example Measured distance from launch pad to the altitude finder is 150 meters. The angle on the altitude finder for the rocket at apogee is 38 degrees.

Scale drawing:

Let 1 cm = 50 meters.



h is measured to be 2.4 cm. The height then is 2.4 x 50 = 120 meters.

The altitude finder scale gave a value of 119 meters. This compares quite nicely to the 120 meters calculated using triangulation.

The heights reached can easily be determined by using the tangents of the tracked angles rather than by making a scale drawing for each flight.

Activity 1.5 Another piece of data that is quite useful is an accurate measurement of the mass of each rocket just before launching. A balance that measures to the nearest tenth of a gram is sufficient.

For students to make predictions for the height a rocket will go based on the results of data from other launches may or may not work well. One variable that changes from rocket to rocket is the drag. Drag can be affected by the number of fins, the size and shape of the fins, and how the fins were placed on the rocket body. The amount of sanding and sealing done on the fins to reduce drag is also very important.

The teacher might like to see if the students can figure out a way to dtermine heights reached based on mass changes with the drag remaining constant. This can be done by launching the same rocket with different masses. (This can be accomplished by using different masses in a payload compartment or different amounts of clay attached to the base of the nose cone.)

Engines of different power levels (as 1/2A6-2 and A8-3) may be used with the Alpha rockets to provide fun and variety in launches. Data gathered on certain rockets using both engines could be used to make predictions concerning other rockets, and these height predictions could then be checked by actual flights. This can be a good research project or science fair project.

Activity 1.6 The teacher should encourage students to make hypotheses concerning the flights of their model rockets. After hypotheses are formulated, the students should then design controlled experiments to check their hypotheses. When possible the teacher should allow students to collect data to try and disprove their hypotheses. The teacher should always be alert to avoid potential safety hazards in student plans.

Activity 1.7 The teacher should have the students write a three or four page report related to rocketry. Many different sources could be used as references. The five references listed below could be helpful to some students with their chosen topic.

REFERENCES

Akens, David S. 1966. A Picture History of Rockets and Rocketry. Strode Publishers.

A selection of historic rocket and rocketry photographs from early achievements of Tsiolkovsky and Goddard through the 1966 photographic results of Surveyor I's mission to the moon.

Dille, John. 1965. Americans in Space. New York: Harper and Row.

This book gives a very nice history of Robert Goddard's pioneer work in rocketry for the United States. The U.S. race for exploration of space is discussed, and contributions made by Project Mercury's seven original astroanuts are well documented.

Quackenbush, Robert. 1978. The Boy Who Dreamed of Rockets. New York: Parents' Magazine Press.

A nicely done book discussing the life of a very important American rocket expert, Robert Goddard. Dr. Goddard had some 214 patents pertaining to rocketry.

Stine, G. Harry. 1983. Handbook of Model Rocketry. New York: Arco Publishing Company, Inc.

This is a well written book addressing the many important points relating to model rocketry. Major sections of the book are devoted to constructing a rocket, the rocket engine, launch pads and controllers, and how to fly your own rocket.

Von Braun, Wernher and Frederick I. Ordway III. 1966. History of Rocketry and Space Travel.

A comprehensive history, international in scope, illustrated with more than 280 drawings, photographs, and color plates.

APPENDIX A

NAR/HIA MODEL ROCKETRY SAFETY CODE

1. Construction-My model rockets will be made of lightweight materials such as paper, wood, plastic and rubber, without any metal as structural parts.

2. Engines-I will use only pre-loaded factory-made NAR safety-certified model rocket engines in the manner recommended by the manufacturer. I will not change in any way nor attempt to reload these engines.

3. Recovery-I will always use a recovery system in my rocketsthat will return them safely to the ground so that they may be flown again.

4. Weight Limits-My model rocket will weigh no more than 453 grams (16 oz) at lift-off and the engine will contain no more than 113 grams (4 oz) of propellant.

5. Stability-I will check the stability of my model rockets before their first flight, except when launching models of already proven stability.

6. Launching System-The system I use to launch my model rockets must be remotely controlled and electrically operated and will contain a switch that will return to "off" when released. I will remain at least 15 feet from any rocket that is being launched.

7. Launch Safety-I will not let anyone approach a model rocket on a launcher until I have made sure that either the safety interlock key has been removed or the battery has been disconnected from my launcher.

8. Flying Conditions-I will not launch my model rockets in high winds, near buildings, power lines, tall trees, low flying aircraft, or under any conditions which might be dangerous to people or property.

9. Launch Area-My model rockets will always be launched from a cleared area, free of any easy to burn materials, and I will only use flame resistant recovery wadding in my rockets.

10. Jet Deflector-My launcher will have a jet deflector device to prevent the engine exhaust from hitting the ground directly.

11. LaunchRod-To prevent accidential eye injury I will always place the launcher so the end of the rod is above eye level or cap the end of the rod with my hand when approaching it. I will never place my head or body over the launch rod. When my launcher is not in use I will always store it so that the launch rod is not in an upright position.

12. Power Lines-I will never attempt to recover my rocket from power lines or other dangerous places.

13. Launch Targets & Angle-1 will not launch rockets so their flight path will carry them against targets on the ground, and will never use an explosive warhead nor a payload that is intended to be flammable. My launching device will always be pointed within 30 degrees of vertical.

14. Pre-Launch Test-When conducting research activities with unproven designs or methods, I will, when possible, determine their reliability through pre-launch tests. I will conduct launchings of unproven designs in complete isolation from persons not participating in the actual launching.

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